automated transfer vehicle

→ ATV: SERVICING THE INTERNATIONAL SPACE STATION

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European Space Agency

THE ULTIMATE SPACE TUG

ESA's Automated Transfer Vehicle (ATV) is the largest, heaviest and most complex space vehicle ever developed in Europe.

It serves the orbiting International Space Station (ISS) as a cargo carrier, storage facility and as a 'tug' vehicle to adjust the Space Station's orbit.

The versatile craft is an essential European contribution to the regular workings of the Space Station, which now has an operational life extending until at least 2020. Each vehicle brings deliveries of experiment equipment and spare parts as well as food, propellants, air and water for the crews.

The ATV, equipped with its own propulsion and navigation systems, is a multifunctional spaceship, combining the fully automatic capabilities of an unmanned vehicle with human spacecraft safety requirements.

After launch, a high-precision navigation system guides the ATV on a rendezvous trajectory towards the Space Station, where it docks automatically with a precision of around 8 cm while circling Earth at 28 000 km/h.

It remains there as a pressurised and integral part of the complex for up to six months before undocking followed by a controlled reentry into Earth's atmosphere.

Each ATV is a vital means for ISS housekeeping, scientific research and astronaut well-being.

In 2008 the first ATV, *Jules Verne*, delivered 4.5 tonnes of cargo to the Space Station, including food, clothing, propellants, water and oxygen. The average cargo mass of subsequent missions will be 6 tonnes.

ATVs also contribute to ISS operations by performing regular orbit reboosts, debris-avoidance manoeuvres and by removing 5.5 tonnes of waste from the Space Station at the end of their missions.

INDEPENDENT CAPABILITY

The combination of ATV and the powerful Ariane 5 launcher provides Europe with an independent capability to transport equipment to the Space Station, which is important for both political and operational reasons.

By carrying propellants, gases, water and other goods for use on the ISS, Europe contributes in kind towards its share of the Space Station's operating costs.

The ATV was developed and is built under ESA contract by a European industrial consortium led by EADS Astrium.

The second ATV, *Johannes Kepler*, is planned for launch in late 2010 and the third, named *Edoardo Amaldi*, about a year later. At least two more are scheduled at regular intervals after that.

NASA

"Our challenge for the ATVs *Johannes Kepler* and *Edoardo Amaldi* is to implement the valuable lessons learned from the very successful ATV *Jules Verne* and make their performance even better."

Nico Dettmann, ESA ATV Programme Manager

ATV LAUNCH

An ATV mission begins when the craft is launched into orbit by an Ariane 5 from Europe's Spaceport in French Guiana.

After five days, the cargo craft approaches the Space Station to a hold point some 30 km behind the ISS. Here, the ATV's computers begin final approach manoeuvres, eventually closing with the ISS at a relative speed of a few centimetres a second whilst both vehicles orbit Earth at around 8000 kilometres an hour.

During the highly active phases of an ATV flight – from launch to docking, and from departure to reentry – a 60–person team at the ATV Control Centre in Toulouse, France, works in three adjacent control rooms closely monitoring all procedures.

NASA

Space Station crewmembers inside the docked ATV *Jules Verne*.

APPROACH AND DOCKING

The ATV's state-of-the-art automatic rendezvous system uses a series of sensors for accurate navigation and the precision docking.

Orbital navigation is carried out by a startracker (which identifies different constellations in the sky and uses the information to calculate the spacecraft's orientation in space) and a GPS receiver (which gives positional information by measuring the angles between orbiting satellites).

Relative GPS (comparing ISS and ATV GPS data) is used for navigation from a distance of 30 km to 250 m. Then the final docking manoeuvre employs a videometer's eye-like sensors which analyse images of an emitted laser beam, reflected from locations around the Russian docking port on the ISS.

During the last 250 m of ATV's final approach, the videometer automatically recognises the reflected target patterns and calculates the distance and direction to the docking port.

Once the ATV is securely attached to the ISS, astronauts enter its cargo section and begin removing the various payload items.

At the same time, the craft's fuel and water supply tanks are connected to the Space Station's own plumbing system, allowing astronauts to release oxygen and nitrogen directly into the ISS.

END OF MISSION

ATVs remain at the Space Station for up to six months, during which time the crew gradually removes all the cargo and replaces it with unwanted material.

Once its mission is complete, the ATV hatch is sealed and the spacecraft undocked before its engines place it on a steep flight path that causes it to break up high above the ocean.

In the process of burning up, it disposes of all the waste material that was no longer needed on the Space Station.

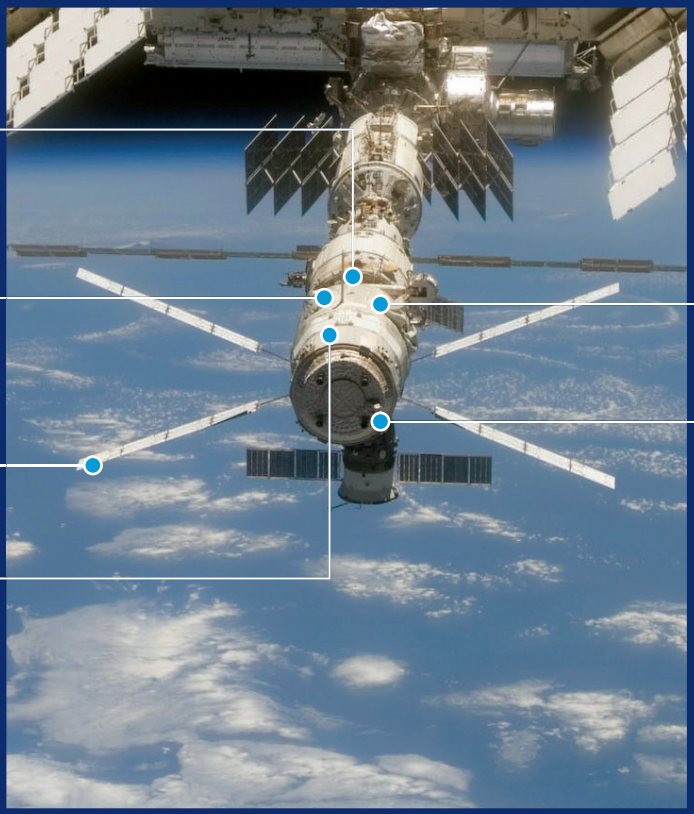
ATV CHARACTERISTICS

The ATV comprises two modules: the Service Module and the Integrated Cargo Carrier.

The 45 m³ pressurised volume of the Integrated Cargo Carrier is based on ESA's Columbus laboratory, which in turn is derived from Italy's Multi-Purpose Logistics Module (MPLM), a cargo carrier used on the Space Shuttle.

Each ATV has room for up to eight equipment racks loaded with modular storage cargo elements.

The ATV's structure also incorporates storage tanks for transporting drinking water, refuelling propellant for the Space Station's own propulsion system, and air (oxygen and nitrogen) for the crew.



NASA

"The unique technologies developed in Europe for the ATV is something we can build on for the future."

Simonetta Di Pippo, ESA Director of Human Spaceflight

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ADVANCED REENTRY VEHICLE

The successful mission of ATV *Jules Verne* in 2008 demonstrated technologies and capabilities that can be developed and adapted in the future for new spacecraft.

One possibility being studied is deriving from the ATV a vehicle capable of returning material to Earth, which would provide a significant boost to the Station's research capabilities after the US Space Shuttle is retired.

ATV's Integrated Cargo Carrier would be replaced by a cargo reentry capsule, equipped with a heatshield, allowing it to bring back hundreds of kilograms of cargo and experiments. The ATV Service Module would be evolved to serve as the Service Module of the new vehicle.

Such a project – named the Advanced Reentry Vehicle (ARV) – would inherit technology developed for ESA's Atmospheric Reentry Demonstrator, which flew successfully in 1998, as well as benefiting from work on past space transportation system concepts.

Further into the future, the ATV's pressurised cabin could be transformed into a reentry capsule for carrying people, making it a fully-fledged crew transport vehicle.

ESA/Ducros

"ISS operations after retirement of the Space Shuttle open up new opportunities. As well as enhancing Station utilisation, an ARV would give Europe further knowhow and autonomy."

Marco Caporicci, ESA ARV Project Manager

NASA

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